# ATTACHMENT A

obturation. Special techniques, to be discussed later, have been devised to overcome the loss of ***resistance form***.

In Mexico, Kuttler has shown that the narrowest waist of the apical foramen usually lies at the dentinocemental junction (Fig. 3–10).[24] He established this point at approximately 0.5 mm from the outer surface of the root in most cases. The older the patient, however, the greater this distance becomes, because continued cemental formation builds up the apex. One is also reminded that the dentinocemental junction, where ***resistance form*** is established, is the apical termination of the pulp. Beyond this point, one is dealing with the tissues of the periodontal ligament space, not the pulp.

The fact must also be established that the apical ***foramen*** does not always lie at the exact apex of the root. Often, canals exit laterally, short of the radiographic apex. This may be revealed by careful scrutiny of the film with a magnifying glass, or by placing a curved exploratory instrument to the exact ***canal*** length and repeating the X-ray examination. The Japanese reported from a native cohort that the apical foramen exits the exact apex only 16.7% of the time in maxillary anterior teeth.[15]

### Extension for Prevention

Seidler once described the ***ideal*** endodontic cavity as a round, evenly tapered space with a minimal opening at the foramen.[34] Because one is working with round, tapered materials, one would think this ideal is easily achieved, particularly when one thinks of root canals as naturally round and tapered. As seen in the anatomic drawings in this chapter, however, few canals are round throughout their length. Thus one must usually compromise from the ideal, attempting to prepare the round tapered cavity, but knowing that filling techniques must be used to make up for the variance from ideal. This is why single point fillings, whether silver or gutta-percha, are seldom used.

The ***extension*** of the cavity preparation throughout its entire length and breadth is necessary, however, to ensure ***prevention*** of future problems. Peripheral enlargement of the canal, to remove all the debris, followed by total obturation is the primary preventive method.

**Fig. 3-10.** Instruments and filling material should terminate short of cementodentinal junction, narrowest width of canal and its termination at foramen. This point is often 0.5 to 1.0 mm from apex.[24]

### Instruments and Methods for Radicular Cleaning and Shaping

Before launching into a detailed or even a broad discussion of the methods and shapes of canal cavity preparation, a description of the instruments and methods used in cleaning and shaping the canal is necessary. "The order of their appearance" during preparation will also be discussed: basic endodontic instruments, irrigation, exploration for canal orifices, exploration of the canal, and length of tooth determination. Then the techniques of intraradicular cavity preparation will follow in detail. Pulpectomy will be discussed later.

### Basic Endodontic Instruments

After years of relative inactivity, a remarkable upsurge in endodontic instrument development and refinement has recently developed. Historically, very little was done to improve the quality or standardization of instruments until the 1950s, when two research groups started reporting on the sizing, strength, and materials that went into hand instruments.[46-48] After the introduction of standardized instruments,[49] about the only changes made were the universal use of stainless rather than carbon steel and the addition of smaller (No. 6 and 8) and larger (No. 110 to 150) sizes as well as color coding and the re-emergence of power-driven instruments.

By 1962, a working committee on standardization had been formed including manufacturers and the American Association of Endodontists. This group evolved into the present-day International Standards Organization (ISO). It was not until 1976, however, that the first approved specification for root canal instruments was published (ADA Spec. No. 28), 18 years after Ingle and Levine first proposed standardization in 1958.[47]

**Endodontic Instrument Standardization.** Before 1958, endodontic instruments were manufactured without benefit of any established criteria. Although each manufacturer used what seemed to be a unified size system, the numbering (1 through 6) was entirely arbitrary. An instrument of one company rarely coincided with a comparable instrument of another company. In addition, there was little uniformity in quality control or manufacture, no uniformity existed in progression from one instrument size to the next, and there was no correlation of instruments and filling materials in terms of size and shape.

Beginning in 1955, a serious attempt was made to correct these abuses, and in 1959 a new line of standardized instruments and filling material was introduced to the profession.[49]

1. A formula for the diameter and taper in each size instrument and filling material was agreed on.

2. A formula for a graduated increment in size from one instrument to the next was developed.
3. A new instrument numbering system based on instrument metric diameter was established.

This new numbering system, using numbers from 10 to 100, was not just arbitrary, but was based on the diameter of the instruments in hundredths of a millimeter at the beginning of the tip of the blades, a point called $D_1$ (diameter 1) (Fig. 3–11), and extending up the blades to the end point of the blades at $D_2$ (diameter 2)—16 mm in length.

The full extent of the shaft, up to the handle, is in three lengths: standard, 25 mm; long, 31 mm; and short, 21 mm. The long instruments are often necessary when working in canines over 25 mm long, whereas the shorter instruments are helpful in second and third molars or with the patient who cannot open widely.

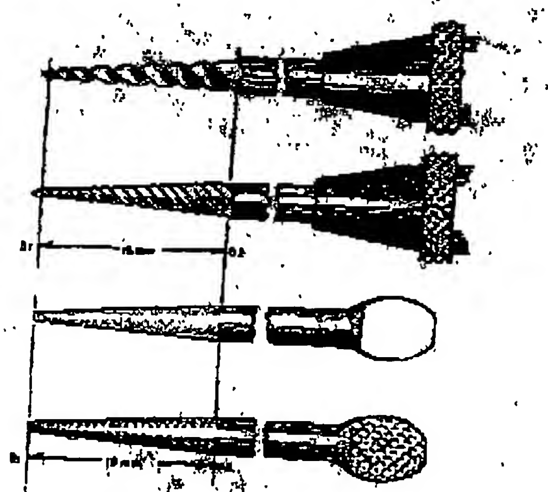
After initial resistance by many manufacturers, who felt that the change would entail a "considerable investment in new dies and machinery to produce them," manufacturers, worldwide, eventually accepted the new sizing.

Ultimately, to maintain these standards, the American Association of Endodontists urged the American Dental Association and the United States Bureau of Standards to appoint a committee for endodontic instrument standardization. A committee was formed and, after considerable work and several drafts, presented a specification package that slightly modified and embellished Ingle's original standardization. These pioneering efforts reached international proportions when a worldwide collaborative committee was formed: the International Standards Organization (ISO), consisting of the *Fédération Dentaire Internationale*, the World Health Organization, and the American Dental Association Instrument Committee. The ISO has now formulated international specifications using the ADA proposal as a model.

In January 1976, the American Standards Institute granted approval of "ADA Specification No. 28 for endodontic files and reamers" (Fig. 3–12). It established the requirements for diameter, length, resistance to fracture, stiffness, and resistance to corrosion. It also included specifications for sampling, inspection, and test procedures.[50] The final revision to ADA Specification No. 28 for K-type files and reamers in March 1981 highlighted 25 years of work to achieve international standardization (Table A–1).[50]

Initially, manufacturers of endodontic instruments worldwide adhered rather closely to these specifications. Some variations have been noted, however, in size maintenance (both diameter and taper), surface debris, cutting flute character, torsional properties, stiffness, cross-sectional shape, cutting tip design and type of metal[51–57] (Fig. 3–13). More recently, Stenman and Spangberg were disappointed to note that the dimensions of root canal instruments are becoming poorly standardized, and that few brands are now within acceptable dimensional standards.[58]

Cormier and Seto have both warned of the importance of using only one brand of instruments because of discrepancies in instrument size among manufacturers.[53,54] Seto also notes that grinding the flutes in files rather than twisting them "does not improve the strength or ductility of the instrument . . . (and) may also create more undesirable fluting defects."[54] Autoclaving apparently has no clinically significant deleterious effects on endodontic instruments.[59,60]



3–11. Original recommendation for standardized instruments. Cutting blades 16 mm in length are of the same size numbers as standardized filling points. The number of the instrument is determined by diameter size at $D_1$ in hundredths of millimeters. Diameter 2 (D2) is uniformly 0.32 mm greater than D1. (From Ingle JI: Transactions of the Second International Conference on Endodontics. Edited by L. I. Grossman. Philadelphia, University of Pennsylvania, 1958.)

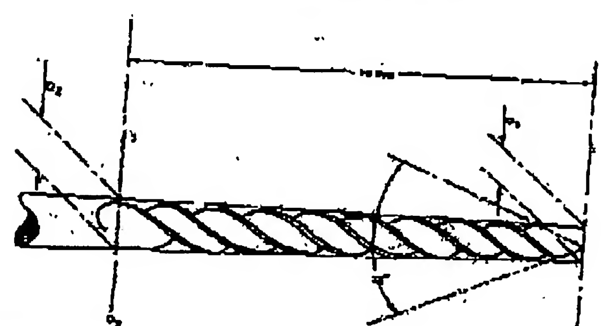


Fig. 3–12. Standardized dimensions of root canal files and reamers established by ISO. Two modifications from Ingle's original proposal are an additional measurement at D3, 3 mm from D1 and specification for shapes of tip—75°, plus or minus 15°. The taper of the spiral section must be at 0.02 mm gain for each mm of cutting length. Specifications for a noncutting tip are forthcoming.

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Table 3–1. Dimensions in Millimeters. Revision of ADA Specification No. 28 Added Instrument Sizes 00 and 110 to 150 to the Original Specification

| Size | Diameter (Tolerance, ± 0.02 mm) $D_1$ mm | $D_2$ mm | $D_3$ mm | Handle Color Code |
|---|---|---|---|---|
| 00 | 0.08 | 0.40 | 0.14 | Gray |
| 10 | 0.10 | 0.42 | 0.16 | Purple |
| 15 | 0.15 | 0.47 | 0.21 | White |
| 20 | 0.20 | 0.52 | 0.26 | Yellow |
| 25 | 0.25 | 0.57 | 0.31 | Red |
| 30 | 0.30 | 0.62 | 0.36 | Blue |
| 35 | 0.35 | 0.67 | 0.41 | Green |
| 40 | 0.40 | 0.72 | 0.46 | Black |
| 45 | 0.45 | 0.77 | 0.51 | White |
| 50 | 0.50 | 0.82 | 0.56 | Yellow |
| 55 | 0.55 | 0.87 | 0.61 | Red |
| 60 | 0.60 | 0.92 | 0.66 | Blue |
| 70 | 0.70 | 1.02 | 0.76 | Green |
| 80 | 0.80 | 1.12 | 0.86 | Black |
| 90 | 0.90 | 1.22 | 0.96 | White |
| 100 | 1.00 | 1.32 | 1.06 | Yellow |
| 110 | 1.10 | 1.42 | 1.16 | Red |
| 120 | 1.20 | 1.52 | 1.26 | Blue |
| 130 | 1.30 | 1.62 | 1.36 | Green |
| 140 | 1.40 | 1.72 | 1.46 | Black |
| 150 | 1.50 | 1.82 | 1.56 | White |

* New diameter measurement point ($D_3$) was added 3 mm from tip of cutting end of the instrument. Handle color coding is official.

In 1992 Schilder patented a different concept of instrument sizing. Marketed as ProFile Series 29*, the instrument sizes progress by a constant percentage increase (29%) from one instrument to the next, rather than by a metric increase of 0.05 mm between sizes in the standardized ISO instruments.

Although starting with a 0.029 mm increase between files No. 1 and No. 2 ProFiles rapidly gain in metric size to a 0.069 mm increase between sizes No. 4 and No. 5, comparable to ISO sizes 25 and 30.

ProFiles come in sizes "00" to "11," are made of stainless or nickel titanium, and have noncutting tips. No testing has been reported to date.

### ISO Grouping of Instruments

In due time, the International Standards Organization–*Fédération Dentaire International* committee grouped root canal instruments according to their method of use:

Group I: Hand use only—*files*, both K-type (Kerr) and H-type (Hedstroem); *reamer* K-type; and broaches, pluggers and spreaders.

Group II: Engine-driven latch type—same design as Group I but made to be attached to a handpiece. Also included are paste fillers.

* ProFile, Tulsa Dental Products (USA)

Group III: Engine-driven latch type—drills or reamers such as Gates-Glidden (G-type), Peeso (P-type) as well as a host of others—A, D, O, KO, T, M-type reamers and the Kurer Root-Facer.

Group IV: Root canal points—gutta-percha, silver, paper.

The ISO grouping of endodontic instruments makes convenient a discussion by group of their manufacture, usage, cutting ability, strengths and weaknesses.

**ISO GROUP I—K-Type Instruments, Reamers, or Files.** First designed in 1915 by the Kerr Manufacturing Co., these are the most widely copied and extensively manufactured endodontic instruments worldwide. Now made universally of stainless rather than carbon steel, K-type instruments are usually produced by grinding graduated sizes of round "piano" wire into either a square or triangular configuration. A second grinding operation properly tapers these pieces. To give the instruments the spirals that provide the cutting edges, the square or triangular stock is then grasped by a machine that twists it counterclockwise a programmed number of times—tight spirals for files, loose spirals for reamers. The cutting blades that are produced are the sharp edges of either the square or the triangle. In any instrument these edges are known as the "rake" of the blade. The more acute the angle of the rake, the sharper the blade.

There are approximately twice the number of spirals on a file as on a reamer of a corresponding size (Fig. 3–14). Some manufacturers are now grinding in the spirals rather than twisting them. Originally the cross section of the K-file was square, the reamer triangular. Recently, manufacturers have started using either configuration to achieve better cutting and/or flexibility. Cross section is now the prerogative of individual companies.

*Reamers.* As the name implies, reamers are used for drilling. They cut by being tightly inserted into the canal, twisted clockwise one-quarter to one-half turn to engage their blades into the dentin, and then withdrawn—penetration, rotation, and retraction.[61] The cut is made during retraction. The process is then repeated, penetrating deeper and deeper into the canal. When working length is reached, the next size instrument is used, and so on.

Reaming is the only method that produces a round, tapered preparation, and this only in perfectly straight canals. In such a situation, reamers can be rotated one-half turn before retracting. In a slightly curved canal, a reamer should be rotated only one-quarter turn. More stress may cause breakage. The heavier reamers, size 50 and above, can almost be turned with impunity. The new nickel titanium instruments are much more flexible and resist breakage even in small sizes.

Files as well as reamers can be used for reaming, but conversely, reamers do not work well as files—their flutes are too widespread to rasp.

*Files.* The tighter spiral of a file (Fig. 3–15) establishes a cutting angle (rake) that achieves its principal cutting action on withdrawal, although it will cut in the push motion as well. The withdrawing cutting action

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Accurate indications, adverse reactions, and dosage schedules for drugs are provided in this book, but it is possible they may change. The reader is urged to review the package information data of the manufacturers of the medications mentioned.

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